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COMPARATIVE STUDY ON COMPOSITIONAL AND FUNCTIONAL PROPERTIES OF CASSAVA- AND CORN-BASED MALTODEXTRIN

Summary

Cassava-based maltodextrins with different dextrose equivalent (DE = 5, 10, 15 and 20) were prepared using two different enzymes, namely Termamyl 120L and Ban 480L (Novo Nordisk, Denmark). The molecular distribution oligosaccharide component (DP 1 – 7) was characterized and compared with commercial corn-based maltodextrin of the same DE. For all DE's, cassava-based maltodextrins prepared by Termamyl enzyme comprised more high molecular weight saccharides than corn-based maltodextrins. The profiles of saccharide component of cassava-based maltodextrin from Ban were comparable to those of corn-based ones. The shape and size of maltodextrins from two starch bases were different, presumably due to different processing. Corn-based maltodextrins were bigger in size. However, most properties including moisture content, water sorption and viscosity of both cassava- and corn-based maltodextrins were similar.

Introduction

Maltodextrin is a starch hydrolysis product and is usually classified by the extent of hydrolysis as described by the dextrose equivalent (DE), i.e. the percentage of the total reducing sugars, expressed as dextrose, present in the sample to the total dry substance. According to the U.S. Food and Drug Administration, maltodextrin is a non-sweet nutritive saccharide polymer that consists of D-glucose units linked primarily by α-1,4-bonds and has a dextrose equivalent of less than 20. It is prepared as a white powder or concentrated solution by partial hydrolysis of corn or potato starch with safe and suitable acids and enzymes [4]. Maltodextrin is found to be useful for many applications including spray-drying aids for flavors and seasonings, carriers for synthetic

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sweeteners, flavor enhancers, fat replacers, and bulking agent [5]. Typically, the food industry regards maltodextrin to be corn-based products. However, maltodextrin products can also be produced from other starchy sources, such as rice and cassava.

Maltodextrin of the same DE may have different functional properties, depending to some extent on its molecular characteristics. The products of the same DE may contain a different distribution of molecules; most are medium size. Large molecules are few and undesirable as they can precipitate after dissolved. Small molecules do not precipitate but they provide the product sweetness. The molecular composition of maltodextrin can be varied depending on the process (acid or enzyme, type of enzyme used etc.), processing condition (enzyme and starch concentration, temperature, pH) and starch types. Since starches of different sources have different molecular structure (amylose/amylopectin ratio, degree of branching, chain length distribution etc.), maltodextrin can also be expected to have different characteristics.

This paper aims to investigate the molecular composition and describe some functional properties of maltodextrin prepared from cassava starch using two enzymes and to compare the products with commercial corn-based maltodextrins of a comparable dextrose equivalent.

Materials and methods

Materials: Cassava starch was obtained from the factory in Thailand. Two types of enzyme were used including Termamyl 120L (from *Bacillus licheniformis* with the activity of 120 KNU; 1 KNU is the amount of enzyme used to hydrolyze the starch 5.26g per hour according to the standard method of Novo Nordisk) and Ban 480L (from *Bacillus amyloliquefaciens* with the activity of 480 KNU; Novo Nordisk Co., Bagsvaerd, Denmark). Corn-based maltodextrins including Maltrin M040, M100, N150 and M200 were obtained commercially from Grain Processing Corp. (USA) [2].

Preparation of cassava-based maltodextrin: Starch slurry (30% by weight) containing 400 ppm of calcium ion was cooked in the presence of enzyme and incubated at the controlled temperature (100 and 75°C for Termamyl 120L and Ban 480L, respectively) for different times to produce maltodextrin with different DE (Table 1). The reaction was terminated by adjusting the pH to 3 and boiling for 5 min. The hydrolysate was then filtered and spray-dried (BUCHI 190 Mini Spary Dryer, Germany).

Dextrose equivalent: DE values of samples were determined by the Lane and Eynon titration with Fehling's solution [3].

Compositional analysis: The macromolecular components of maltodextrins were determined by High Performance Size Exclusion Chromatography (HPSEC) using one Ultrahydrogel linear and two Ultrahydrogel 120 columns connected in series (Waters Corporation, MS) according to the method of Govindasamy et al. [1]. Oligosaccharide components of maltodextrins were quantified by the High Performance Anion Ex-

change Chromatography with Pulse Amperometric Detector (HPAEC-PAD, Dionex BioLC, Dionex, CA, USA) using CarboPac PA-100 (2 x 250 mm) and two mobile phases including 5mM and 0.5M sodium acetate in 100mM sodium hydroxide. The descriptive ratio, the ratio of the sum of the percentages of saccharides (dry basis), having a DP1 – 6 devided by DE values was also reported.

Table 1

Conditions (enzyme concentration and hydrolysis time) used for preparing cassava-based maltodextrin with different dextrose equivalent values.

Condition	Dextrose equivalent (DE)			
	5	10	15	20
*Termamyl 120L**				
Enzyme concentration (% by weight)	0.1	0.1	0.5	0.5
Hydrolysis time (min)	60	360	30	60
*Ban 480L***				
Enzyme concentration (% by weight)	0.1	0.1	0.5	0.5
Hydrolysis time (min)	10	30	10	30

*Starch concentration was 30% by weight at 100°C, pH 6.0.

** Starch concentration was 30% by weight at 75°C, pH 6.0.

General properties: The scanning electron micrographs of maltodextrin samples was observed under JEOL scanning electron microscopy (JSM-5310, England) at 10-KV acceleration and magnified at 3,000x. The content of moisture was determined by drying the sample at 105°C until constant weight. The pH value of 20% (by weight) solution was recorded. The bulk density of maltodextrin was measured according to the method of Wang and Wang [5]. The sample was filled into a graduated cylinder with an exact volume and the weight of the sample was recorded as the loose-filled weight. The cylinder was then subjected to mixer vibration and the volume of packed sample recorded. The water sorption isotherm of maltodextrin was obtained by incubating the samples under the different relative humidity conditions (21, 31, 51, 67, 80 and 92%) according to Wang and Wang [5]. The viscosity of maltodextrin solution (20% dry weight) was measured at 25°C using a Brookfield viscometer (Model DV-III, spindle # 0 at 10 to 240 min^{-1}, Brookfield Engineering Lab, inc.) and the shear rate and shear stress were recorded.

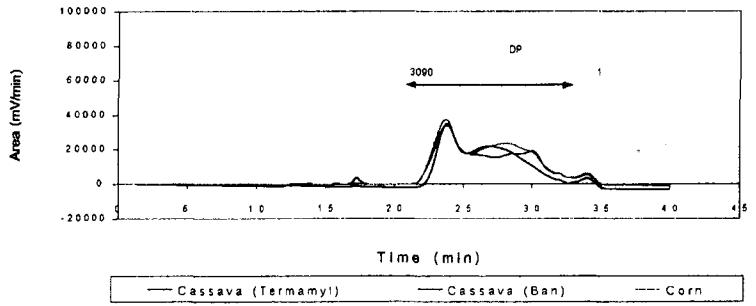
Results and discussion

Cassava-based maltodextrins of DE 5, 10, 15 and 20 were prepared by two bacterial enzymes, namely Termamyl 120L and Ban 480L. The measured DE of all prepared samples was in the range of ±1 except maltodextrin DE 10 prepared by enzyme

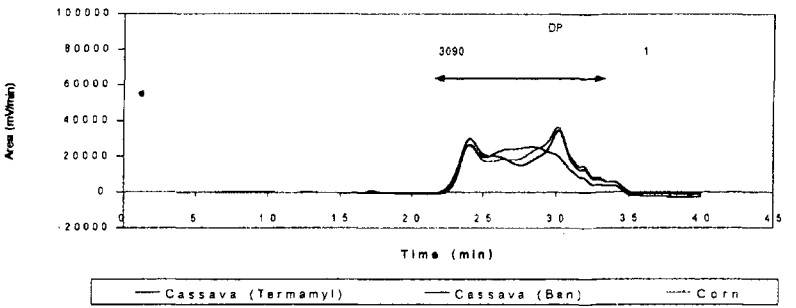
Termamyl and DE 20 prepared by enzyme Ban (Table 2). All corn-based maltodextrin had the measured DE within the range of product specification (GPC, 1999). Figure 1 presents the molecular distribution of cassava- and corn-based maltodextrins with different DE. For all DE's, cassava-based maltodextrins prepared by Termamyl enzyme comprised of more high molecular weight saccharides than corn-based maltodextrins. The profiles of saccharide component of cassava-based maltodextrin from Ban were comparable to those of the corn-based ones (Figure 1). This trend was still observed when the quantity of oligosaccharides (DP 1–7) was investigated (Figure 2). Mainly, cassava-based maltodextrin from Termamyl contained a lower amount of oligosaccharides than the corn-based samples having the same DE. However, the descriptive ratio of corn-based samples were not higher than the cassava-based as the DE values were slightly higher.

General properties of casasva- and corn-based maltodextrins were investigated. All samples were dry with very low moisture contents (less than 8%; Table 2). The pH of cassava- and corn-based samples was different. This assumed to different processes. For all DE's, cassava-based samples, regardless of the enzyme type, had the lower loose density than the corn-based ones, but the packed density were close. Therefore, the percentage of compressibility, the ratio of packed density to loose density, of cassava-based sampels were higher than the corn-based maltodextrins. This was presumably due to the shape and size of maltodextrin products. Corn-based maltodextrins for all DE's were bigger sizes than the cassava-based samples. Moreover, the cassava-based maltodextrins were sphere-like (Figure 3), so they could pack properly and readily. These different starch-based maltodextrin could expect to have different flowability.

The water adsorption capacity is also an important characteristics of maltodextrin. As the dry powder, maltodextrin can uptake water to some extent when placed in a very humid atmosphere. Maltodextrin of high DE can uptake more water (Figure 4). No significant difference in water sorption of cassava- and corn-based maltodextrin was observed. When maltodextrin was dissolved, the solution of all samples, regardless of enzyme used and starch based, had similar viscosity (Table 2)and shear stress (Figure 5).



(a)



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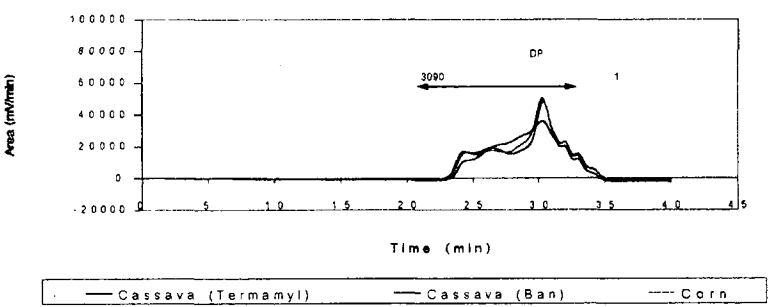

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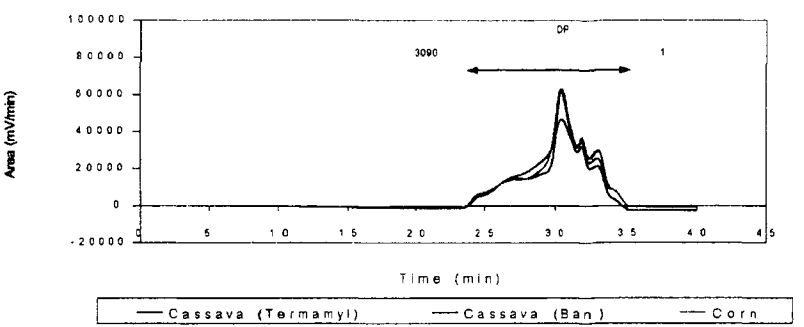

(d)

Fig. 1. Molecular distribution of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-bas ed maltodextrin with different dextrose equivalent (a) DE=5 (b) DE=10 (c) DE=15 and (d) DE=20.

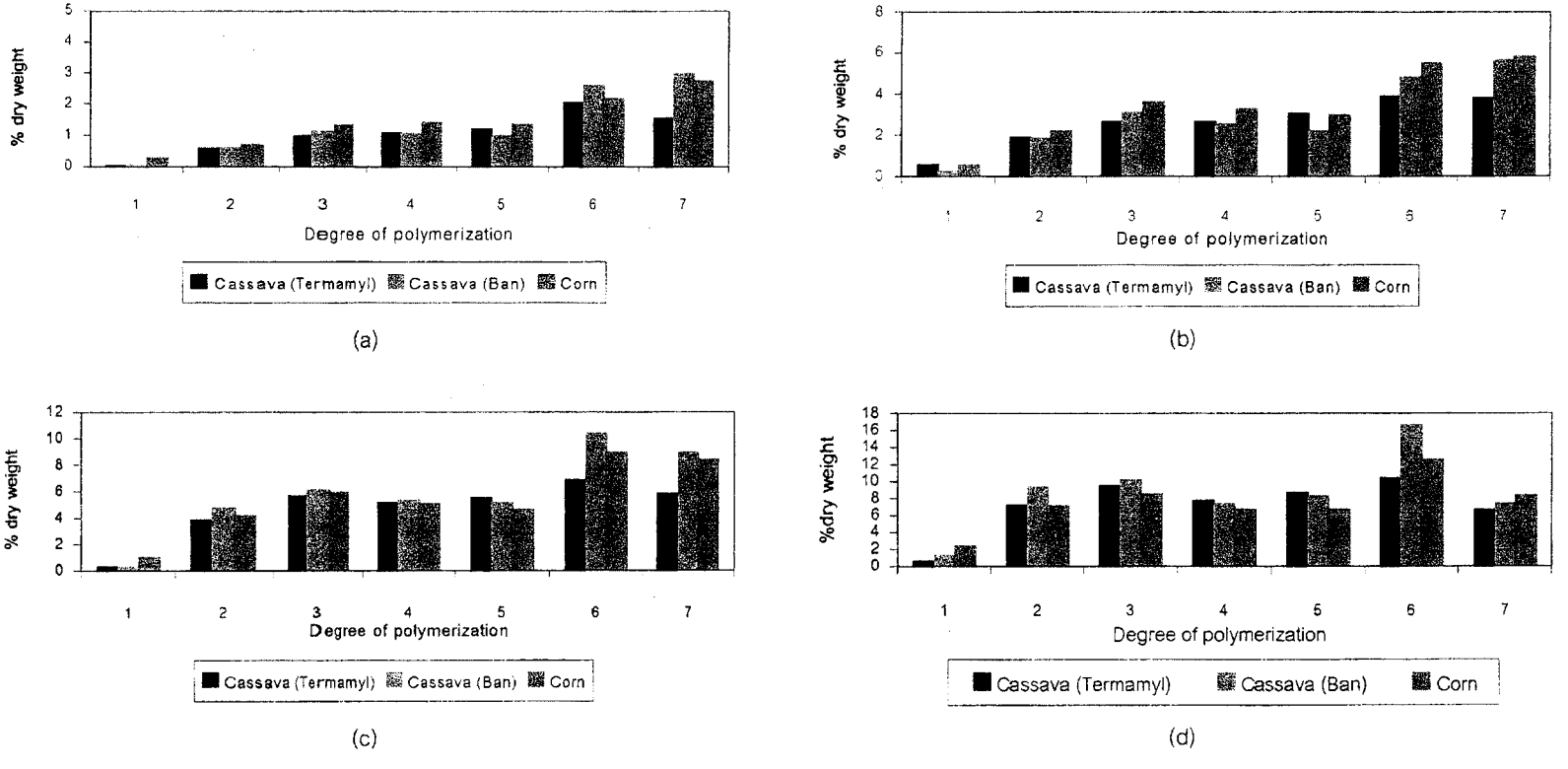

Fig. 2. Oligosaccharide component of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-based maltodextrin with different dextrose equivalent (a) DE=5 (b) DE=10 (c) DE=15 and (d) DE=20.

Table 2

Properties of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-based maltodextrin with different dextrose equivalent (DE = 5, 10, 15 and 20).

Property	Cassava (Termamyl 120L)				Cassava (Ban 480L)				Corn			
	5	10	15	20	5	10	15	20	5	10	15	20
Measured DE	5.37± 0.25	8.43± 0.24	15.08± 0.47	20.62±0. 40	5.70± 0.33	9.83± 0.08	15.63±0. 11	22.58±0. 10	6.65± 0.36	11.76± 0.34	16.26± 0.10	22.46± 0.27
Average DP	21.5	9.5	7.0	5.0	20.7	12.3	7.0	4.7	17.9	10.1	7.4	5.0
Descriptive ratio[1]	1.11	1.74	1.81	2.15	1.14	1.51	2.06	2.36	1.09	1.54	1.83	1.96
Moisture content (%)	7.89± 0.44	6.70± 0.05	5.25± 0.06	6.21±0.0 6	4.87± 0.05	4.88± 0.04	3.83± 0.11	3.58± 0.04	8.71± 0.11	6.88± 0.26	8.57± 0.13	5.38± 0.03
pH	7.45± 0.01	6.97± 0.13	7.12± 0.08	7.04±0.0 6	8.37± 0.06	7.58± 0.03	7.59± 0.07	7.59± 0.01	4.25± 0.00	4.30± 0.01	4.42± 0.01	4.54± 0.01
Loose density (g/l)	0.26± 0.01	0.36± 0.01	0.33± 0.01	0.37±0.0 1	0.27± 0.01	0.29± 0.01	0.35± 0.01	0.43± 0.01	0.35± 0.01	0.45± 0.00	0.45± 0.01	0.46± 0.00
Packed density (g/l)	0.52± 0.02	0.64± 0.01	0.62± 0.01	0.64±0.0 1	0.55± 0.02	0.54± 0.02	0.67± 0.02	0.76± 0.03	0.53± 0.00	0.63± 0.00	0.63± 0.00	0.66± 0.01
Viscosity at 20% solid (cP)	8.03± 0.23	5.09± 0.04	3.10± 0.05	2.72±0.0 4	8.48± 0.31	5.12± 0.08	2.94± 0.53	2.60± 0.13	7.33± 0.23	4.20± 0.13	3.26± 0.00	2.62± 0.00

[1]Descriptive ratio is the ratio of the sum of the percentages of saccharides (dry basis), having a DP1 – 6 devided by DE values.

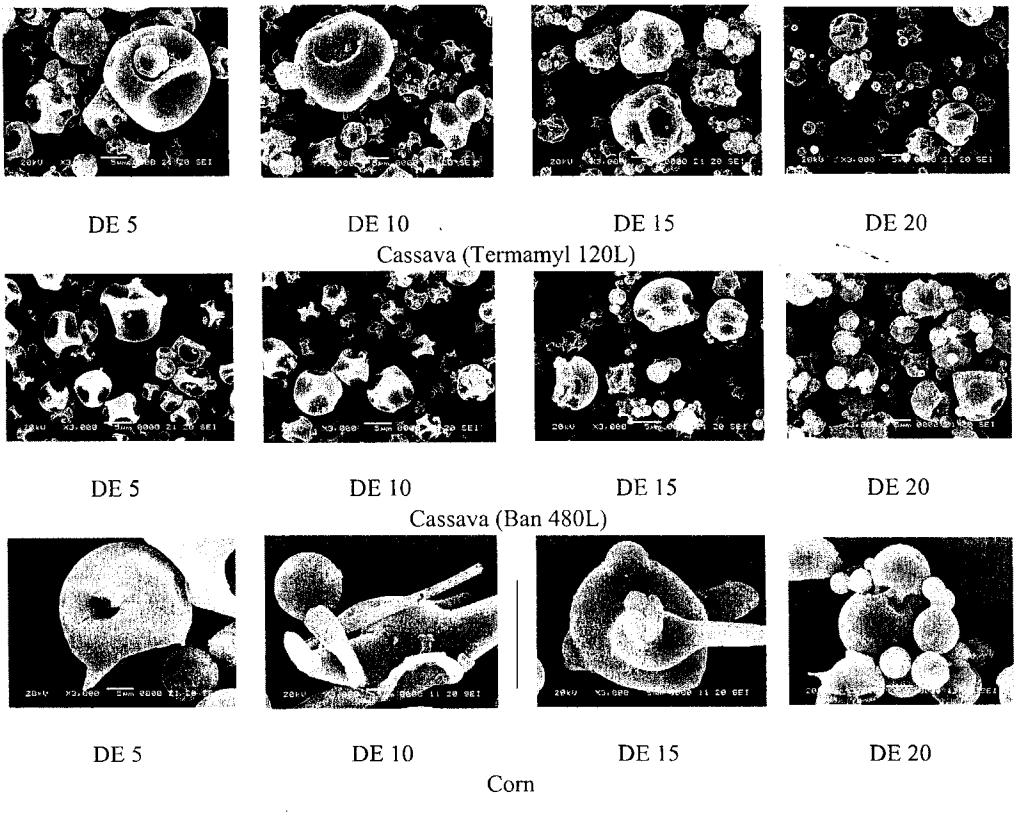

Fig. 3. Scanning electron micropgraph at 3,000x of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-based maltodextrin with different dextrose equivalent (DE = 5, 10, 15 and 20).

Conclusion

This work suggests that although cassava- and corn-based maltodextrin had slightly different molecular profiles, most properties were similar. However, other physical and biological properties such as sweetness, osmolality, gelation and adsorption by humans of these products should be further investigated and compared to support the use of different starch-based maltodextrins.

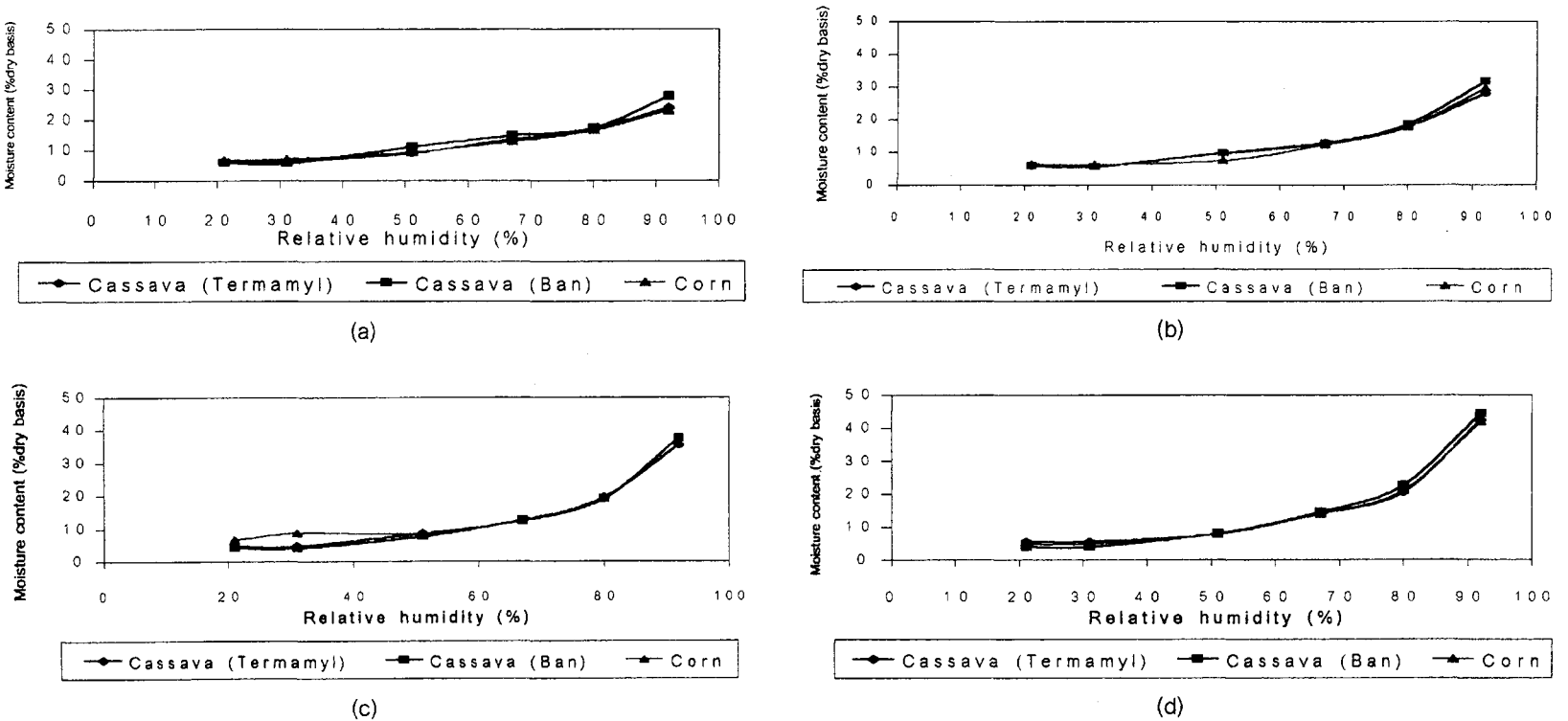

Fig. 4. Water sorption isotherm of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-based maltodextrin with different dextrose equivalent (a) DE=5 (b) DE=10 (c) DE=15 and (d) DE=20.

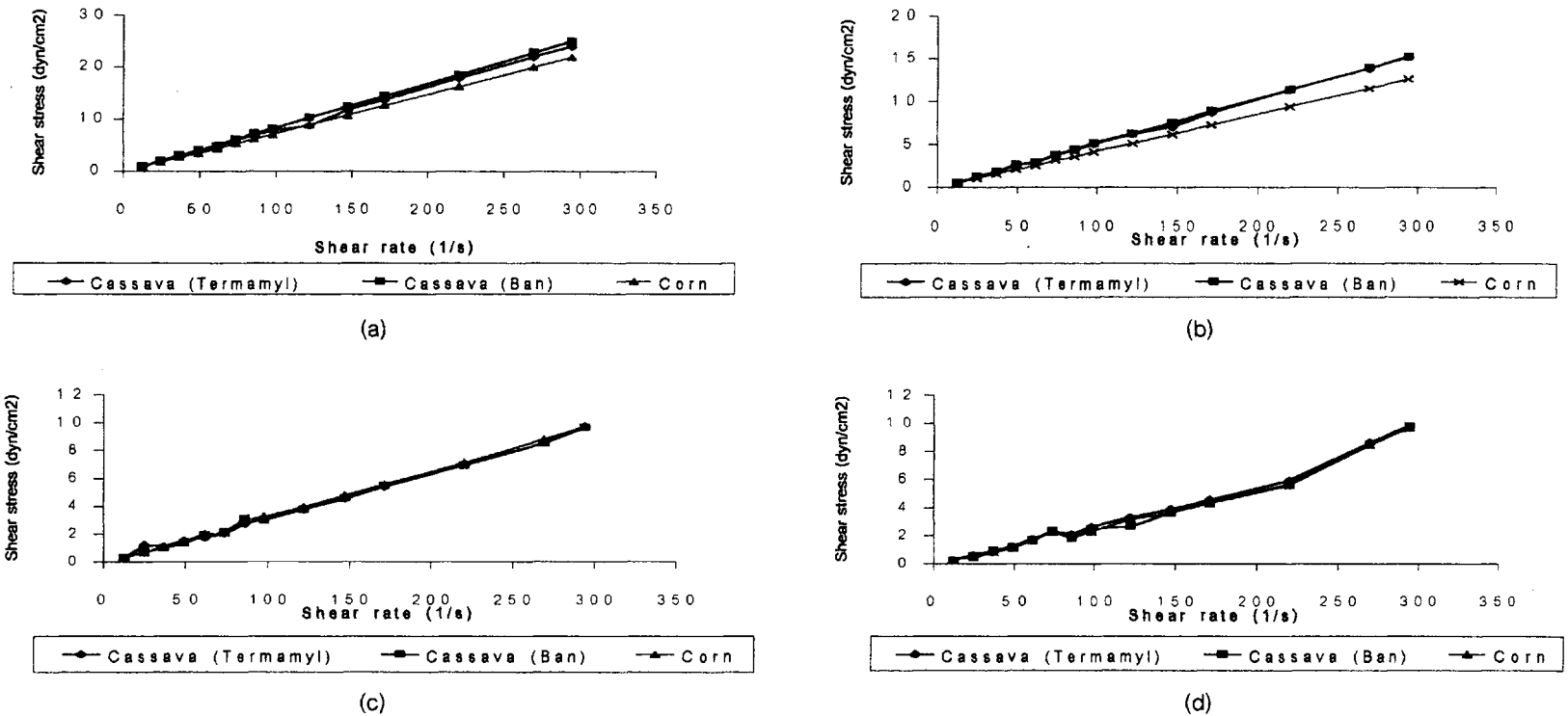

Fig. 5. Shear rate and shear stress of cassava-based maltodextrin prepared by two enzymes (Termamyl 120L and Ban 480L) and commercial corn-based maltodextrin with different dextrose equivalent (a) DE=5 (b) DE=10 (c) DE=15 and (d) DE=20, measured at 20% solutin at 25°C.

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PORÓWNANIE SKŁADU I WŁAŚCIWOŚCI FUNKCJONALNYCH MALTODEKSTRYN TAPIOKOWYCH I KUKURYDZIANYCH

Streszczenie

Maltodekstryny tapiokowe o różnym równoważniku dekstrozowym (DE = 5, 10, 15 i 20) otrzymano przy użyciu dwu różnych enzymów duńskiej firmy Novo Nordisk. Rozkład frakcji i składniki oligosacharydowe (DP = 1–7) zostały scharakteryzowane i porównane z handlowymi maltodekstrynami kukurydzianymi o tym samym DE. Maltodekstryny tapiokowe otrzymane przy użyciu enzymu Termamyl 120L w całym zakresie DE zawierały sacharydy o wyższym ciężarze cząsteczkowym niż odpowiednie maltodekstryny kukurydziane. Profile składowych sacharydowych maltodekstryn topiokowych otrzymanych enzymem Ban 480L były porównywalne z profilami maltodekstryn kukurydzianych. Kształt i rozmiar maltodekstryn z obu skrobi różniły sie od siebie zapewne z powodu odmiennej obróbki. Maltodekstryny kukurydziane miały większe cząsteczki. Jednak większość właściwości maltodekstryn kukurydzianych i topiokowych włącznie z zawartością wilgoci, sorpcją wody i lepkością była podobna.